CHAPTER 3. Reference Method and Optional Modeling Capabilities for Alternative Calculation Methods (ACMs)

Candidate ACMs may have more capabilities than the minimum required. These *optional capabilities* can be approved for use with the ACM for compliance purposes. Optional capabilities are those capabilities of an ACM that are not required as a Required Capability and for which there may or may not be specific capability tests in Chapter 5. Applicants wishing to receive approval of their ACM must meet all of the documentation requirements of the capabilities proposed and be prepared to defend the technical accuracy of any optional modeling capabilities during the ACM approval process.

The Commission does not require a program to have these capabilities, accept inputs for optional capabilities (except for *optional compliance capabilities*), or use these procedures in order to become certified. However, an ACM may offer optional capabilities to the user provided the specific capabilities have been certified by the Commission or the ACM meets all special conditions, conforms to all required calculational procedures, and passes certified tests for optional capabilities previously approved by the Commission for another ACM. The special conditions may include the capability to accept special input and produce special output for the optional capability. The Commission must review separate test results and specifically approve the ACM for these additional optional capabilities. The assumptions for the optional capabilities must be included in the vendor's submittal for optional capabilities as described in Sections 3.3 through 3.6. **For the purpose of compliance the use of any optional capability is considered an exceptional condition requiring special additional documentation to verify the distinctive features in the drawings and specifications related to the optional capability and to verify the particular inputs that are used to characterize the optional capability.**

An ACM's optional or additional capabilities must have specific tests, specific input and specific output requirements and these all must be approved by the Commission in writing. **Optional capabilities and any non-required ACM inputs that modify ACM results in such a way that can result in the ACM failing to meet the approval criteria for any test in Chapter 5 are specifically prohibited unless their use has been approved by the Commission as an optional capability. This is especially true for inputs and capabilities that cannot be modeled using the reference computer program.** This does not mean that ACMs may not differ in their inputs. For example, one ACM may accept wall heat capacity as an input, while another may use volume, density, and specific heat of the component wall materials to calculate the heat capacity, while another still may assume a heat capacity as a function of wall type. But no ACM may have an input for mass of phase change material in the wall and material phase change temperature without specific prior written approval of that capability and its associated inputs, outputs, and internal defaults and restrictions.

If any optional capability is modeled, the option must be specified on the appropriate compliance form automatically generated by the ACM. Additionally, ANY optional capability used in compliance must be listed on the Performance Summary form, PERF-1, page 2, as an exceptional condition which requires additional special documentation.

The ACM approval application (see Appendix A) must list and describe (or reference the description in the ACM User's Manual) all optional capabilities which are certified for compliance.

3.1 Compliance - Optional Capabilities

The following optional compliance capabilities may be allowed by nonresidential ACMs. Optional compliance capabilities include partial compliance and compliance for additions and alterations. There are

specific output requirements for these options which are described in this Section and Section 2.7--Required Standard Reports.

3.1.1 Additions & Alterations

If the ACM is approved for the optional capabilities of alterations or automated calculation of Addition plus Existing Building, the **ACM must produce approved additional forms for existing building components and systems in accordance with the procedures described in Section 2.7 - Required Standard Reports.**

The Addition plus Existing Building calculation may also be performed by performing two separate runs. The first run is used to determine the budget for the existing building prior to the addition or alterations and the budget for a standard building similar to the existing building. These budgets are taken from the output for the proposed and standard building energy consumption using either the diagnostic output (if the existing building does not comply) or information from the PERF-1. The addition is modeled separately in the second run to determine the target budget for the addition space from the budget for the standard building for the addition. The budgets for these spaces are combined to determine a target budget for the combination of the two spaces. Budgets given in energy use per square foot per year are area weighted while budgets given in energy use per year for the total area can be added together.

The altered existing building plus the addition can then be modeled and the proposed building budget from that run must be less than the combined budget for the spaces above to get compliance.

When the addition is modeled separately and the existing HVAC system is to be expanded to serve both existing and new spaces, the HVAC system for the addition shall be modeled as a separate HVAC system of the same type as the existing HVAC system with similar efficiency characteristics (EER, COP, FPI, etc.)

3.1.2 Alteration or Addition Plus Altered Existing

ACMs that allow automated analysis of alterations of an existing building or an addition in conjunction with an existing building with alterations must perform compliance analysis of additions and alterations according to Section 149 of the Standards. This procedure also requires special and specific input and reporting procedures that complement the reporting requirements for a new building alone.

ACMs may use a two pass compliance procedure for an Addition plus Existing Building analysis similar to that used for the residential standards and described in the Residential ACM Approval Manual. See Section 3.1--Optional Compliance Capabilities--for more information on this technique. This technique requires the modeling of two different proposed designs with the ACM: (1) existing building and (2) the altered existing building combined with the proposed addition.

3.1.3 Output Reports

There are special output requirements for existing building components and characteristics that are passed directly to the standard design and compared against themselves in the custom budget process. In general, these must be reported on separate forms and in a distinctly different typestyle from new or altered building components and characteristics in output reports. To accommodate all printers this is done by using lowercase and UPPERCASE output to differentiate these inputs. See Section 2.7--Required Standard Reports--for more details.
To accommodate the optional capabilities of partial compliance and modeling additions with the existing building and alterations and deter circumvention of the standards, **all ACMs MUST report all new or**

altered user-entered building components and descriptive information completely in UPPERCASE TYPE. ACMs with the capabilities for partial compliance, modeling additions with the existing building or modeling alterations in an existing building **MUST report all information on existing, previously-approved building components that are not altered in lowercase type.** This is to insure that the local enforcement agency can readily determine the use of existing building components that do not have to meet the requirements of the building energy efficiency standards and distinguish these modeled components from those that are new or have been altered.

3.1.3.1 Graphical Output

Description: ACMs may include the ability to produce graphical output to facilitate the plan checking process. As part of the output documentation, ACMs may graphically show building's orientation, floors, walls, roofs, windows, skylights, thermal zones, and building cavities such as courtyards and atria. ACMs may either:

1. Draw isometrics showing all four sides of the building with adequate detail to visually verify the building's exterior features and interior cavities, or

2. Draw two-dimensional drawings showing side views of the building with adequate detail to visually verify the building's exterior features.

The graphical output shall:

a) Show the building orientation,

b) Show the envelope features such as exterior walls, exterior floors, roofs, exterior windows and skylights, and etc., including their size by showing their dimensions and location,

c) Show each footprint indicating the boundaries and dimensions of the footprint and the boundaries of occupancy and system areas associated with each footprint including occupancy types and system types, and boundaries and dimensions for building's interior cavities.

d) Show the boundaries of the building's thermal zones.

e) Show the overall ~~U-value~~U-factors of the opaque surfaces as well as the glazing on the drawing or in a tabulated form with reference to the drawing.

3.2 Overview of the Modeling Process

The modeling rules in the optional modeling approach are organized to facilitate the ACM software development and building modeling. The steps for modeling a building are as follows:

1. The user shall define construction types and layers of the proposed building envelope assemblies. The ACM shall model the proposed assemblies according to user inputs.

2. The ACM shall build the reference design envelope assemblies using the same construction types, materials and heat capacities as the proposed assemblies The ACM shall exclude any exterior and

interior insulation but, instead, shall adjust the cavity insulation R-value to meet the overall ~~U-value~~U-factor requirements for the assembly type and the climate zone.

3. The user shall define the building's footprint(s). A footprint is the plan view of a floor or a group of floors. A footprint includes building's interior cavities such as courtyards and atria. A building has one or more footprints. Each floor may have its own footprint or several floors of a building may have the same footprint. Floors have the same footprint if:

    a) They have identical plan views, i.e., having the same shape and area after including all building's interior cavities,

    b) They have identical floor to ceiling distances, and

    c) They have identical window patterns.

    This will reduce the amount of user inputs for modeling the envelope features of high-rise buildings which may only have a few different footprints. For each footprint, the user shall model the envelope features of the lowest floor having that footprint and the ACM shall duplicate these features for all floors of the high-rise building having that footprint.

    A footprint is surrounded by exterior walls separating the conditioned spaces from the ambient air and by demising walls separating the conditioned space from enclosed unconditioned spaces. By definition, indirectly conditioned spaces are considered conditioned spaces and are included in the footprint area. Footprints are modeled using the coordinates of their vertices relative to the building's reference point.

4. For every footprint, the user shall model exterior walls using the assemblies modeled in paragraph (1) above. The ACM shall model demising walls as *adiabatic* surfaces. ACMs may use an equivalent method to DOE-2's "FLOOR-MULTIPLIER" to model floors of the building which have the same footprint. Users must not model interior walls separating conditioned spaces within a building. ACMs shall account for the thermal capacity of interior walls according to the rules which will be described later in this manual. Exterior and demising walls are modeled using the coordinates of their vertices relative to the building's reference point.

5. The user shall describe all interior cavities--atria and courtyards--by specifying the coordinates of their vertices relative to the building's reference point for each and every footprint or floor where the cavity's plan view changes. Atria are considered as conditioned spaces but courtyards are considered as outside (ambient air). If an atrium is indirectly conditioned, it shall be modeled as part of adjacent spaces according to the rules which will be described later in this manual.

7. The user shall describe the occupancy areas by specifying the coordinates of the occupancy area's vertices relative to the building's reference point. An occupancy area is the space used by an occupancy type selected from Table 2-1.

8. The user shall describe building's system areas by specifying the coordinates of the area's vertices relative to the building's reference point. A system area is the space served by an HVAC system. For each HVAC system serving the building, the user must input the area that the system serves.

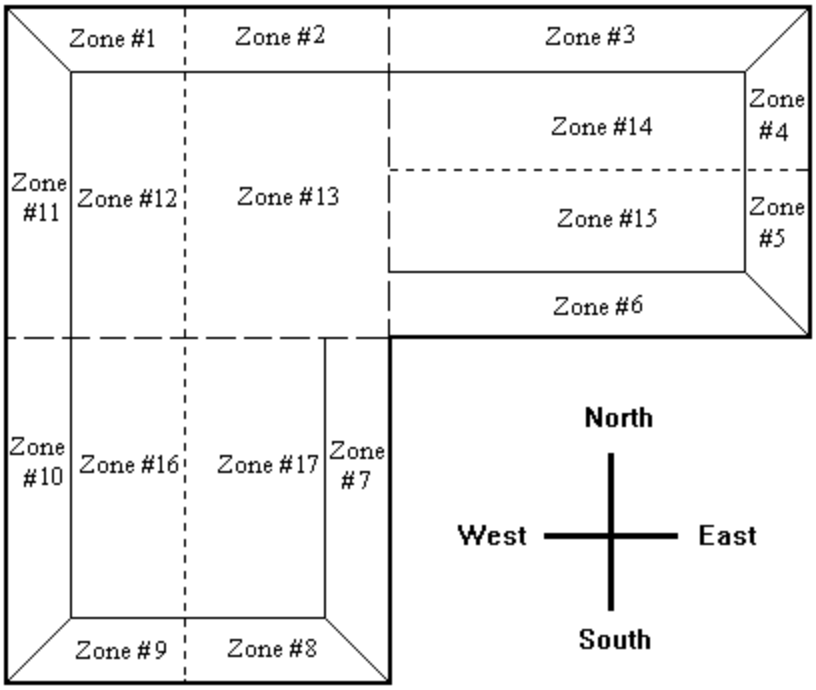
    1. The ACM shall automatically create thermal zones in accordance with the building geometry, occupancy areas, system areas and space types (interior or exterior) using the rules described in this manual. Each exterior space facing a different orientation or is within 45 degrees of that orientation is modeled as a separate exterior zone. All interior zones within a system area having the same occupancy type are combined. If a space has several occupancy types and is served by several HVAC systems, each combination of occupancy type, system type, space type (interior or

exterior), and whether the exterior zone is next to a North facing wall, East facing wall, South facing wall, and West facing wall is modeled as a separate thermal zone.

Thermal zones less than 300 ft^2 are combined with adjacent zones within the same HVAC system. Exterior zones next to courtyards must not be combined with other exterior zones even if they face the same orientation.

ACMs shall model the interface between thermal zones as air walls. ACMs shall model interior floors as input by the user, but must not allow modeling any interior walls. Walls separating conditioned spaces from indirectly conditioned spaces are considered interior walls. The heat capacity effect of interior walls and furniture shall be approximated by the program according to rules described in Section 2.2.2.13. The following example will illustrate zoning of a building with three occupancy types and six HVAC systems:

Example: Heavy lines show the building's footprint. Short dashed lines are boundaries separating system areas, long dashed lines are boundaries separating occupancy areas (from Table 2-1), and light solid lines show the thermal zone boundaries, which must be created by ACMs according to the rules described in Section 3.5.1.2.



3.3 Building Shell - Optional Capabilities

ACMs may use the following optional modeling approach for modeling the building shell. Unless otherwise specified in this section, ACMs shall determine the standard design according to the requirements of Section 2.2, Required Modeling Capabilities for the Building Shell.

All ACMs must receive inputs for each different opaque surface (wall, roof/ceiling, or floor) that separates conditioned from unconditioned space or the ground, including each demising wall (which consequently includes each party wall.) These inputs include construction framing type, orientation and tilt, location and area for each exterior surface. An ACM must also allow the user to enter inputs to determine heat transfer

and heat capacity characteristics of exterior opaque surfaces for the proposed design. The heat capacity of standard design exterior surface is identical to the heat capacity of the proposed design exterior surface. Based on this heat capacity, the standards specify a required ~~U-value~~U-factor for the exterior surface that is used as the heat transfer characteristic for the standard design exterior surface.

For all exterior surfaces/assemblies it is assumed that the ~~U-value~~U-factors listed in the building standards include an exterior air film R-value of 0.17 h-ft^{2}-^{o}F/Btu, which the reference method strips off and replaces with a simulated outside air film resistance. Azimuthal orientation and tilts of surfaces must be entered to the nearest degree.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being "All". An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as "All".

All ACMs must separately report information about demising walls, fenestration in demising walls, exterior walls, and fenestration in exterior walls. Demising walls and demising wall fenestration separate conditioned and enclosed unconditioned spaces. Party walls are always considered to be demising walls when they separate spaces controlled or occupied by different tenants. For the purpose of compliance, the adjacent enclosed spaces not controlled by the tenant of the given space or by a single manager of the building are unconditioned. This assumption means that party walls are treated as demising walls and adjacent tenant spaces are modeled as enclosed unconditioned spaces. To avoid modeling adjacent spaces that are not part of the permit, for purposes of standards compliance, an ACM must assume that the demising wall is adiabatic and no heat transfer occurs through it.

3.3.1 Building Footprint

3.3.1.1 Footprint Identifiers

Description: A unique alphanumeric identifier for each footprint of the building. A footprint is the plan view of a floor which includes both directly and indirectly conditioned spaces and building cavities such as atria and courtyards but excludes unconditioned spaces.

Atria are considered conditioned spaces. If no HVAC system is specified for an atrium, ACMs shall assume that it is indirectly conditioned. Courtyards are considered as outside with ambient air. Walls, floors, and ceilings separating conditioned spaces from courtyards are considered exterior walls, floors, and roofs.

A footprint is surrounded by exterior walls separating conditioned spaces from the ambient air and by demising walls separating conditioned spaces from enclosed unconditioned spaces.

Floors of a building with identical plan view (having the same shape and area including building's interior cavities), floor to ceiling height, and window patterns

have the same footprint.

3.3.1.2 Floor Identifiers

Description: A unique alphanumeric identifier for each floor or a group of floors of the building having the same footprint identifier.

3.3.1.3 Number of Floors with the Same Footprint

Description: The number of floors having the same footprint.

DOE Keyword: FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must accept input for the number of floors that have the same footprint identifier according to the construction documents of the building.

Modeling Rules for Reference Design (All): The reference design shall use the same number of floors as the proposed design.

3.3.1.4 Footprint Area

Description: The total area of each footprint including directly and indirectly conditioned spaces and the building's interior cavities such as courtyards and atria.

A footprint is surrounded by exterior and demising walls with the exception of those separating the space from courtyards.

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: **For each footprint** of the proposed design, ACMs shall accept input for the area according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same footprint area as the proposed design.

3.3.1.5 Footprint Geometry

Description: Footprint geometry is described by the coordinates of its vertices defining the exterior perimeter of the footprint. The User must define the footprint geometry of the floor or the lowest floor of a group of floors having that footprint relative to the building's fixed reference point.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: **For each footprint** of the proposed design, ACMs shall accept input for the footprint vertices of the floor or the lowest floor of the building having that footprint according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same footprint vertices as the proposed design.

3.3.1.6 Geometry of Building's Interior Cavities

Description: The geometry of a building's interior cavities are described by the coordinates of the cavity vertices relative to the building's fixed reference point. Building's interior cavities include courtyards and atria.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The user shall describe all interior cavities--atria and courtyards--by specifying the coordinates of their vertices for each floor that the cavity's plan view changes even if those floors have the same footprints. ACMs shall accept input for the vertices according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same cavity vertices as the proposed design.

3.3.2 Above-Grade Envelope

3.3.2.1 Footprint Identifiers

Description: Footprint Identifier as described above.

3.3.2.2 Exterior Partitions

Description: Above-grade exterior partitions surrounding each footprint that separate a conditioned space from the ambient air, attic space, crawl space, courtyard, or unconditioned spaces that are not enclosed. Exterior walls, raised floors, roofs, and ceilings are exterior partitions.

Return air plenums are considered conditioned spaces and must be modeled as part of the adjacent conditioned space.

3.3.2.3 Rectangular Exterior Partitions

Description: The area of rectangular exterior partitions for a footprint are defined by specifying the width of the partition and a height equal to the total height of the floor.

DOE Keyword: EXTERIOR-WALL
WIDTH
HEIGHT
FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each exterior partition of each floor, ACMs shall receive inputs for the height and width as they occur in the construction documents. The reference program shall use the DOE-2 Keyword "FLOOR-MULTIPLIER" to model identical floors belonging to the same footprint.

Modeling Rules for Reference Design (All): The standard design shall model each exterior partition with the same height and width as the proposed design.

3.3.2.4 Non-Rectangular Exterior Partitions

Description: The area of non-rectangular exterior partitions are defined by specifying the coordinates of the partition's vertices relative to a fixed reference point on the plane of the partition. The partitions height is equal to the total height of the floor.

DOE Keyword: EXTERIOR-WALL
X, Y
FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each exterior partition of each floor, ACMs shall receive inputs for the coordinates of its vertices as they occur in the construction documents. The reference program shall use the DOE-2 Keyword "FLOOR-MULTIPLIER" to model identical floors belonging to the same footprint.

Modeling Rules for Reference Design (All): The standard design shall model each exterior partition with the same coordinates for the vertices as the proposed design.

3.3.2.5 Positions of Exterior Partitions

Description: The coordinates describing positions of exterior partitions surrounding each footprint relative to the building's fixed reference point.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall receive inputs for coordinates describing positions of the exterior partitions of the proposed building as they occur in the construction documents. ACMs shall also verify the connectivity of the building's exterior envelope including demising partitions (see Section 2.2.2.5). If this check fails, the ACM shall abort the compliance run and issue a message indicating which exterior partitions and/or demising partitions are not connected.

Modeling Rules for Reference Design (All): The reference design shall position the exterior partitions in the same manner as they occur and are modeled in the proposed design.

Note: ACMs shall not include in the model removed exterior and demising partitions as part of an alteration.

3.3.2.6 Positions of Fenestration Products

Description: The coordinates describing positions of the fenestration products in exterior partitions relative to a fixed reference point on the partition.

DOE Keyword: X , Y, SETBACK

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall accept position coordinates of fenestration products in exterior partitions as shown in the construction documents. ACMs shall also verify that the fenestration product is within the specified partition. If the verification fails, ACMs shall abort the compliance run and issue a message to the user that the

verification has failed.

Modeling Rules for Reference Design (All): Positions of fenestration products in exterior partitions shall be modeled in the same manner as they occur and are modeled in the proposed design.

Note: ACMs shall not include in the model any removed fenestration as part of an alteration.

3.3.2.7 Self Shading

Description: ACMs may model shading of building surfaces by other portions of the building, such as one wing of a building shading another wing from direct sunlight.

DOE Keyword: SHADING-SURFACE
SHADING-DIVISIONS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall model any *building self-shading* as input by the user, according to the plans and specifications for the building.

Modeling Rules for Reference Design (All): The ACM must model *building self-shading* in the standard design exactly as the proposed design.

3.4 Building Occupancy - Optional Capabilities

The user of an ACM must select an occupancy type from certain allowed tables. ACMs that do not have separate selection lists for ventilation occupancy assumptions and all other occupancy assumptions must allow the user to select from the occupancies and sub-occupancies listed in Table 2-1 and Table 2-2 or to select from an officially approved alternative sub-occupancy list that maps into those occupancies. ACMs that have separate occupancy selection lists for ventilation assumptions and other assumptions must use the occupancy selections given in tables in the building energy efficiency standards or approved alternative lists of occupancies. The occupancies listed in Table 1-F in the standards must be used for ventilation occupancy selections and the occupancies listed in Table 1-N in the standards must be used for selecting the remaining occupancy assumptions. Alternatively specific occupancy selection lists approved by the Commission that map into Tables 1-F or 1-N may be used.

A building consists of one or more occupancy types. ACMs may not combine different occupancy types. Tables 2-1 and 2-2 describe all of the schedules and full load assumptions for occupants, lighting, infiltration, receptacle loads and ventilation. Full load assumptions are used for both the proposed design and the reference design compliance simulations.

3.4.1 Occupancy Assignment

3.4.1.1 Occupancy Area

Description: A building consists of an occupancy type or several occupancy types selected from Table 2-1. Each occupancy type occupies a user specified *occupancy area* of the building. ACMs must be able to model a minimum of fifteen (15) occupancy areas. Each occupancy area may include two or more *sub-occupancy areas* selected from Table 2-2.

The reference method will model all interior floors separating occupancy areas and will model air walls between occupancy areas within each floor.

DOE Keyword: X, Y, Z

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must require the user to input the area and coordinates for the vertices of each *occupancy area* relative to the building's reference point. Occupancy area vertices shall define the location of each occupancy type within the building.

The reference program shall model interior floors between *occupancy areas* as they occur in the construction documents. For each floor, the reference program shall model air walls between *occupancy areas.*

ACMs must require the user to input information for each interior floor including construction, orientation, tilt, position and dimensions as it occur in the construction documents.

ACMs must model air walls with zero (0) heat capacity and an overall ~~U-value~~U-factor of 1.0 Btu/h-ft^2-^{o}F.

Default: One occupancy type in the entire building.

Modeling Rules for Reference Design (All): The standard design shall use the same vertices and area for each *occupancy area* as the proposed design.

The reference design shall model the same interior floors and air walls as the proposed design with the same surface areas, locations, thermal properties and construction.

3.4.1.2 Occupancy Types

Description: A modeled building must have at least one defined occupancy type. A default occupancy of "unknown" may be used to fulfill this requirement. Alternative Calculation Methods (ACMs) must model the following *occupancy* types. Occupancies that are considered as subcategories of these occupancies are listed below each occupancy. These occupancy types are also listed in Table 2-1 of this manual:

- Commercial and Industrial Work
  including both general and precision work, barber and beauty shops, laundries, and dry cleaning
- Grocery Store
  including convenience stores
- Industrial and Commercial Storage
- Medical/Clinical
- Office
  including banks & financial institutions, courtrooms, accounting, art, design drafting and engineering spaces
- Other
  including corridors, restrooms, and support areas as well as ALL others not specifically mentioned herein for spaces without lighting plans
- Religious Worship, Auditorium, Convention Center
  including exhibit display areas and lobbies associated with religious worship spaces, auditoriums, and convention centers
- Restaurant
  including dining rooms, kitchens, hotel function areas, bars, cocktail lounges, casinos
- Retail and Wholesale Store
- School
  including classrooms, day care, kindergarten, primary and secondary schools, trade schools, training centers, colleges, universities, research areas, laboratories
- Theater
  including movie theaters, live stage performance theaters, malls, arcades, and atria
- Unknown

Again, ACMs with default occupancies must use the "unknown" occupancy category as a default.

Alternative Calculation Methods (ACMs) must also model the following *sub-occupancy* types. These *sub-occupancy* types are listed in Table 2-2 of this manual. (Note: Some additional sub-occupancies are listed as subcategories of the sub-occupancies listed in Table 2-2):

- Auditorium
- Auto Repair Workshop
- Bank/Financial Institution
  including Banks, Savings & Loans, Credit Unions, Mortgage and Title Insurance
- Bar, Cocktail Lounge and Casino including cabarets, night clubs, bingo parlors and other gaming rooms with smoking
- Beauty Shop
- Barber Shop
- Classroom
  including areas for instructional purposes
- Commercial/Industrial Storage
  including warehouses and storage and stock rooms
- Commercial/Industrial Work - General, High Bay
  including manufacturing areas
- Commercial/Industrial Work - General, Low Bay

including manufacturing areas

- Commercial/Industrial Work - Precision
  Note: the use of this category is an exceptional condition and must be documented on the exceptional conditions checklist.
- Convention, Conference and Meeting Center
- Corridor, Restroom and Support Area
  including all circulation spaces, elevators, escalators, stairways, and janitorial room
- Courtrooms
- Dining Area
  including cafeterias and ballrooms
- Dry Cleaning (Coin Operated)
- Dry Cleaning (Full Service Commercial)
- Electrical, Mechanical Rooms
- Exercising Rooms and Gymnasium
  including day care, health clubs, sports arena, exercise rooms, dojos, spas, pools, saunas, and massage rooms
- Exhibit Display Area and Museum
  including art galleries
- Grocery Sales Area
- High-Rise Residential
- Hotel Function Area
- Hotel/Motel Guest Room
- Kitchen and Food Preparation
- Laundry
- Library - Reading Area
- Library - Stacks
- Lobby - Hotel
- Lobby - Main Entry
  including depots, terminals, and stations
- Lobby - Office Reception/Waiting
- Locker/Dressing Room
- Lounge/Recreation
- Mall, Arcade and Atrium
- Medical and Clinical Care
  including dental care, optical care
- Mixed Occupancy
- Office
  including accounting, counseling, art, drafting, design, insurance, stock & bond brokers, filing areas, conference rooms, mail rooms, telecommunications, and computer areas
- Other
- Religious Worship
  including churches, synagogues, temples, tabernacles, mosques, basilicas, cathedrals, missions, chapels, meditation areas, altars, shrines, worship centers, funeral homes, and memorials
- Retail Sales, Wholesale Showroom
  including pharmacies, drug stores, floral shops, video tape rentals
- Smoking Lounge
- Theater (Motion Picture)
- Theater (Performance)
  including dance halls and discotheques

- Unknown

Please note that this list is comprehensive given the categories "other" and "unknown." *Occupancies* and *sub-occupancies* other than those listed herein cannot be approximated by another *occupancy* or *sub-occupancy* unless that substitution has been approved by the Executive Director of the Commission in writing.

The selection lists accommodate unknown or miscellaneous unlisted occupancies. Any known occupancy not reasonably similar (as determined by the local building official) to an occupancy specified on a Commission-approved list is considered "other." Occupancies unknown to the applicant must use the occupancy type "unknown."

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must require users to specify the occupancy type(s) for the building being modeled. For each occupancy type, ACMs must require

the user to identify if lighting plans are included or have already been submitted. ACMs shall determine the occupancy type as follows:

Lighting compliance not performed. The ACM must require the user to select the *occupancy* type(s) for the building from the occupancies reported in Table 2-1. **The ACM must use the occupancy assumptions of this Table for compliance simulations**.

Lighting compliance performed. The ACM must require the user to select the *occupancy* type(s) for the building from the occupancies reported in Table 2-1. The ACM must also require input for the **percentage** of the *occupancy area* that each *sub-occupancy* type from Table 2-2 occupies**. The areas of sub-occupancy types must not be modeled. The ACM must use the *sub-occupancy* assumptions from Table 2-2 for compliance simulations**.

Tailored lighting and tailored ventilation are permitted as exceptional condition modifications to these default assumptions, but must be reported on the PERF-1 as exceptional conditions and on other applicable compliance forms. The tailored lighting values cannot be traded off for other features. Refer to sections for *Tailored Lighting and Tailored Ventilation* for respective requirements for each of these adjustments.

ACMs must use the same default assumptions, listed in Tables 2-1 through 2-6 of this manual including schedules, occupant densities, outside air ventilation rates, lighting loads, receptacle loads and service water heating loads. ACMs may have a separate occupancy list for ventilation versus other assumptions subject to the constraint that occupancy schedule types cannot be mixed. Users must select occupancy of a given space based upon the proposed or anticipated occupancy

not on the amount of lighting desired. ACM input must emphasize occupancy choices and similarities not lighting choices. ACMs may not report the occupancy default lighting watts per square foot on the screen when the user is selecting occupancies for a space. After the occupancies are selected by the user, the lighting determined from the user's occupancy selection may appear on a separate entry screen as a default entry in the lighting power input if the user has not already entered it.

Modeling Rules for Reference Design (All): ACMs must model the same *occupancy* type(s) and *sub-occupancy* type(s) as the proposed building. ACMs must use the same default assumptions found in Tables 2-1 through 2-6. Tailored lighting and tailored ventilation are permitted as a modification to these default assumptions but must be reported on the PERF-1 exceptional condition list. Refer to sections for *Tailored Lighting and Tailored Ventilation* for respective requirements for each of these adjustments.

3.4.2 Occupancy Lighting

3.4.2.1 Lighting Controls

Description: Lighting controls have specific lighting power adjustment factors as listed in Table 1-L of the standards and any ACM may use these lighting control credits (subject to the requirements and specifications in Section 119 of the standards) just as they would with prescriptive compliance, except for the performance approach, credit cannot be taken for lighting controls that are required by other provisions of the standards, especially Sections 119 and 131. The ACM Compliance Documentation must describe how to determine which controls can be used for credit subject to this restriction. ACMs may explicitly model any of the lighting controls listed in Table 1-L of the standards. The ACM must require the user to input: 1) the area occupancy to which lighting controls are being applied; and, 2) the lighting control strategy or strategies being used. ACMs allow input for lighting control only when an *area occupancy type* has been input for the zone. ACMs with this optional capability must automatically generate a LTG-3, Lighting Controls Credit Worksheet, as part of the compliance documentation.

DOE Keyword: LIGHTING-W/SQFT

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model lighting controls in the proposed design as input by the user according to plans and specifications for the building.

Modeling Rules for Reference Design (New & Altered Existing): The reference design shall model only the lighting controls that are required by other provisions of the standards

Modeling Rules for Reference Design The reference design shall model lighting controls that are installed in the existing building.

(Existing Unchanged):

3.4.2.2 Light Heat to Zone

Description: The reference method assumes that 100% of the heat due to lighting goes to the zone where the lighting is located. An optional capability may vary the lighting heat to the zone from 70%-100% and, consequently, the lighting heat to the return air from 0% to 30%, as a function of the type of lighting fixtures used in the zone. In the absence of persuasive evidence to the contrary, direct user entry of the allocation of lighting heat to the zone and the return air is considered an enforcement problem and is considered grounds for disqualification of an ACM from the approval process.

DOE Keyword: LIGHT-TO-SPACE

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall model the lighting heat-to-space and lighting heat-to-return air bases on the type of lighting fixtures used in the space as shown in the construction documents.

Modeling Rules for Reference Design (New & Altered Existing): The reference design shall use the same lighting heat-to-space and lighting heat-to-return air as the proposed design.

Modeling Rules for Reference Design (Existing Unchanged): The reference design shall model lighting heat-to-space and lighting heat-to-return air based on the lighting fixtures installed in the existing building.

3.5 Building Systems & Plants - Optional Capabilities

This section describes the rules for proposed design assumptions of optional systems and plant capabilities. The ACM must use the performance curves in the DOE-2 Supplement (Version 2.1D). If the described optional capability is not a capability of the Commission's reference computer program, vendors must include the required performance data for that capability. The assumptions in this section may be different than the corresponding assumptions specified in the Required Systems and Plant Capabilities, in order to model optional capabilities accurately.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being “All”. An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as “All”.

3.5.1 Thermal Zoning

3.5.1.1 System Areas

Description: A space or collection of spaces within a building served by an HVAC system. ACMs must be able to model a minimum of fifteen (15) *system areas.*

DOE Keyword: X, Y, Z

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each system serving the building, ACMs must require the user to describe the area being served by the system by inputting the area and coordinates for the vertices of the *system area* relative to building's fixed reference point.

The reference program shall model an air wall between two *system areas* unless an air wall has already been modeled at that location as a boundary for two occupancy areas.

ACMs must require the user to input information for each modeled air wall including orientation, tilt, position and dimensions as they occur in the construction documents.

ACMs must model air walls with zero (0) heat capacity and an overall ~~U-value~~U-factor of 1.0 Btu/h-ft^2-^{o}F.

Default: One system type in the entire building.

Modeling Rules for Reference Design (All): The standard design shall use the same system areas as the proposed design.

The standard design shall model each air wall with the same thermal properties, orientation and tilt, position, and dimensions as the proposed design.

3.5.1.2 Thermal Zones

Description: A space or collection of spaces within a building having sufficiently similar space-conditioning requirements that those conditions could be maintained with a single controlling device. ACMs shall be able to model a minimum of 50 thermal zones.

DOE Keyword: ZONE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall not accept input from the user for modeling thermal zones. Instead, ACMs must divide **each floor** of the building into thermal zones according to the following procedure:

1. Determine the ratio (R) of the floor's total conditioned area to the gross exterior wall area associated with the conditioned space.

2. For each combination of occupancy type, system type, and exterior wall orientation create a perimeter zone. The floor area of each perimeter zone shall be the gross exterior wall area of the zone times R or 1.25, whichever is smaller.

3. ACMs shall model the exterior space adjacent to each wall orientation as a separate exterior zone. ACMs shall include spaces adjacent to walls which are within 45 degrees of each orientation in the zone belonging to that orientation.

4. For cases where R is greater than 1.25, ACMs shall create an interior zone for each combination of occupancy type and system type. The floor area of the interior zone shall be the total system area less the floor area of the perimeter zones created in paragraphs 2 and 3 above.

5. ACMs shall prorate the roof area and the floor area among the zones according to the floor area of each zone. ACMs shall prorate the roof and floor areas among the perimeter zones created in paragraphs 2 and 3 above according to the floor area of each exterior zone.

6. Skylights shall be assigned to interior zones. If the skylight area is larger than the roof area of the interior zone, then the skylight area in the interior zone shall be equal to the roof area in the interior zone and the ACM shall prorate the remaining skylight area among the perimeter zones based on the floor area.

7. For each modeled system area, if the area of the zone is less than 300 ft^2, ACMs shall combine it with its adjacent zone of the same type (interior or exterior) which is served by the same HVAC system.

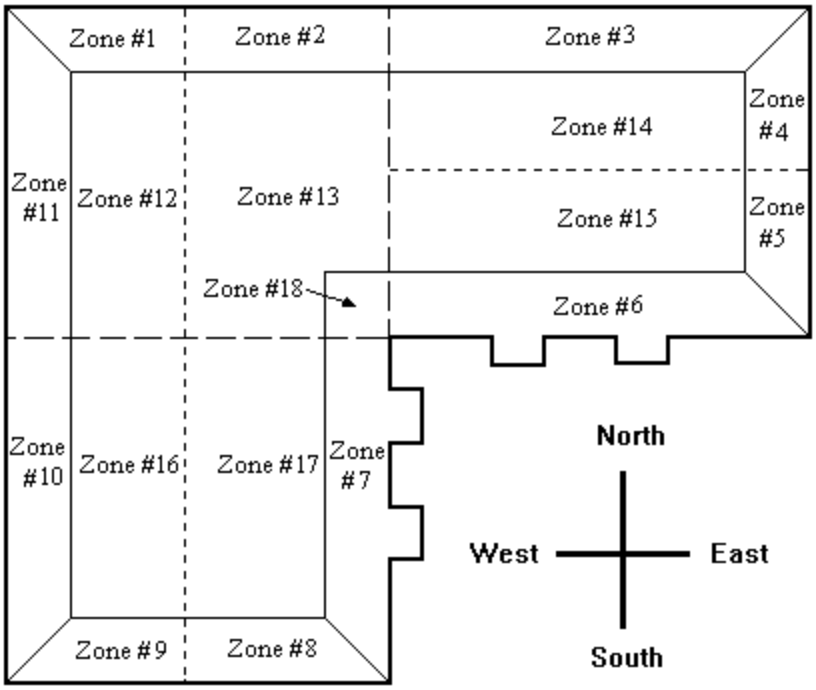
8. Courtyards are considered outside or ambient air. Walls, floors, and roofs separating conditioned spaces from courtyards are exterior walls, floors, and roofs. ACMs shall create an exterior zone for each wall orientation separating the conditioned space from the courtyard. ACMs shall **not** combine these exterior zones with other exterior zones even if their exterior walls have the same orientation.

9. ACMs shall model spaces adjacent to demising walls as interior zones. ACMs shall combine these zones with other interior zones within the same occupancy area and system area.

10. ACMs shall include the exterior wall imperfections (exterior walls extending out for shading windows) in the exterior zone belonging to that exterior wall.

11. ACMs shall model air walls between thermal zones. ACMs must not allow the user to model any interior walls. Walls separating conditioned spaces from indirectly conditioned spaces are considered interior walls. The heat capacity effect of interior walls and furniture shall be approximated by the program according to rules described in Section 2.2.2.13. ACMs shall model the actual interior floors between the thermal zones.

Example 1: Consider the following footprint. Using the above rules 1 through 6 the thermal zones will be as shown in the following drawing:

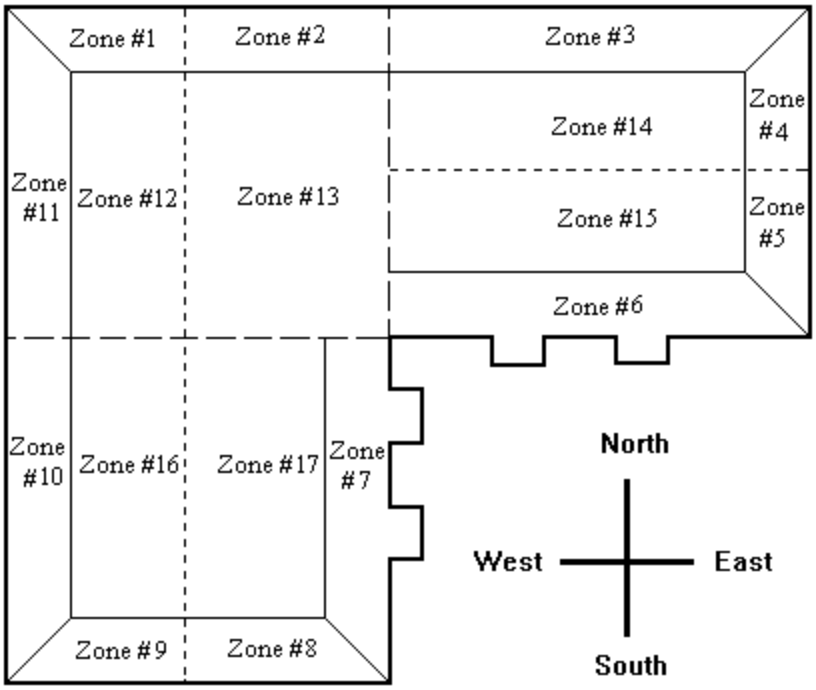


The zone areas are as follows:

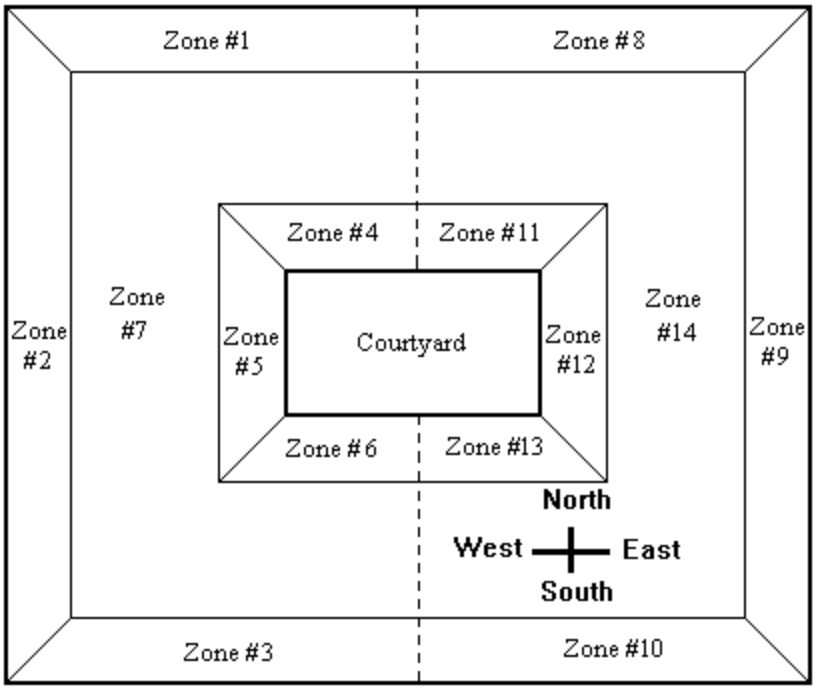
Zone #1	500 ft^2	Exterior
Zone #2	750 ft^2	Exterior
Zone #3	1100 ft^2	Exterior
Zone #4	500 ft^2	Exterior
Zone #5	500 ft^2	Exterior
Zone #6	1300 ft^2	Exterior
Zone #7	1100 ft^2	Exterior
Zone #8	750 ft^2	Exterior
Zone #9	500 ft^2	Exterior
Zone #10	900 ft^2	Exterior
Zone #11	900 ft^2	Exterior
Zone #12	1300 ft^2	Interior
Zone #13	2200 ft^2	Interior
Zone #14	1400 ft^2	Interior
Zone #15	1400 ft^2	Interior
Zone #16	1300 ft^2	Interior
Zone #17	1500 ft^2	Interior

Zone #18 225 ft^2 Interior

Zone #18 is an interior zone whose area is less than 300 ft^2. Therefore, according to rule #7 above, zone #18 is absorbed by the adjacent interior zone within the same HVAC system. The zoning will change as follows:



Example 2: Consider the following footprint. The heavy solid lines are the boundaries separating the conditioned space from the ambient air. The dashed line indicates separation between two different occupancy areas (from Table 2-1). Each occupancy area is served by a different HVAC system. The footprint includes a courtyard in the middle. The zoning will be as follows:

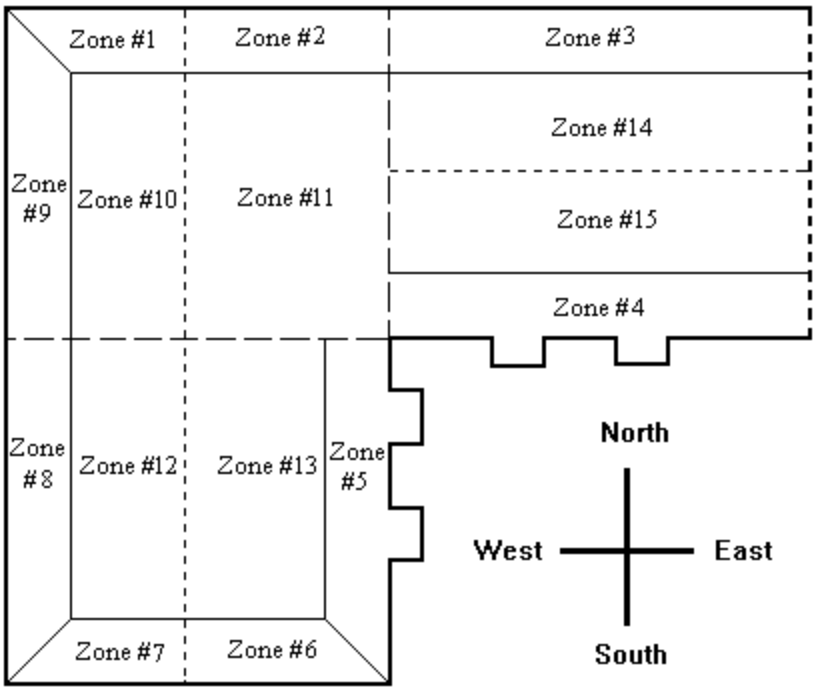


The zone areas are as follows:

Zone #1	1100 ft^2	Exterior
Zone #2	1800 ft^2	Exterior
Zone #3	1100 ft^2	Exterior
Zone #4	500 ft^2	Exterior
Zone #5	700 ft^2	Exterior
Zone #6	500 ft^2	Exterior
Zone #7	6900 ft^2	Interior
Zone #8	1100 ft^2	Exterior
Zone #9	1800 ft^2	Exterior
Zone #10	1100 ft^2	Exterior
Zone #11	500 ft^2	Exterior
Zone #12	700 ft^2	Exterior
Zone #13	500 ft^2	Exterior
Zone #14	6900 ft^2	Interior

All zones are larger than 300 ft^2, therefore, zones will not be combined.

Example 3: This building is the same as the building in example 1, except that the east facing wall is a demising wall.



Modeling Rules for Reference Design (All): ACMs shall model the thermal zones of the reference design in the same manner as they are modeled in the proposed design.

3.5.2 Heating & Cooling Equipment

3.5.2.1 Types of HVAC Systems and Central Plants

Description: ACMs may have the capability to model other types and variations of HVAC systems and central plants. These variations may incorporate alternative designs for:

- Single zone heating and cooling equipment
- Direct and indirect evaporative cooling equipment
- Multiple zone air distribution systems
- Fan volume control
- Water chilling
- Building waste energy recovery
- Building heat rejection
- Renewable energy sources
- Air and water economizer cycles

The Commission has approved a list of these optional capabilities for performance compliance. These capabilities are documented below, along with all required inputs and assumptions for both standard and proposed designs.

DOE Keyword: SYSTEM-TYPE
PLANT-EQUIPMENT
TYPE

INSTALLED-NUMBER

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model the systems and plants of the proposed design as input by the user according to the plans and specifications of the proposed building.

Modeling Rules for Reference Design (New): ACMs shall always determine the standard design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing systems and plants an they occur in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.2 Absorption Cooling Equipment

Description: ACMs may model heat operated (absorption) cooling equipment with the following features:

- *One-stage absorption*. Heat operated water chiller. With this option, the ACM must account for absorber and refrigerant pump energy and purge cycle.
- *Two-stage absorption.* Heat operated water chiller using two stage or double effect concentrator. With this option, the ACM must account for absorber and refrigerant pump energy and purge cycle.
- *Economizer.* For absorption chiller, absorber solution flow to the concentrator is modulated as a function of load.
- *Steam fired.* Absorption chiller uses steam as the heat source.
- *Hot water fired.* Absorption chiller uses hot water as the heat source.
- *Direct fired.* Absorption chiller uses fossil fuel as heat source.

DOE Keyword: PLANT-EQUIPMENT
ABSOR1-CHLR
ABSOR2-CHLR
ABSORG-CHLR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for The ACM shall model absorption equipment in the proposed design as input by

Proposed Design: the user according to the plans and specifications for the building. The ACM shall use performance relationships according to the DOE 2.1 default equipment curves.

Modeling Rules for Reference Design (New): ACMs shall determine the standard design according to the requirements of the Required Systems and Plant Capabilities and Figure 2-1.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.4 Heating Equipment Options

Description: ACMs may model double bundle condensers on cooling equipment for heat recovery.

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model heating equipment options in the proposed design as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.5 Exhaust Heat Recovery

Description: ACMs may model the following methods of heat recovery as input by the user.

- *Heat pipe.* Heat recovered from exhaust air is transferred to supply air via passive heat transfer coil (typically using refrigerant as the medium). No mechanical energy is required for heat recovery. With this option, the ACM must account for additional coil pressure drops.

- *Hydronic loop.* Heat recovered from exhaust air is transferred to supply air via hydronic system including coils in each air stream and water circulation system (run-around system). With this option, the ACM must account for circulating pump energy and accounts for additional coil pressure drops.

- *Heat wheel sensible.* Heat recovered from exhaust air is transferred to supply air via mechanically rotating heat wheel. The wheel may transfer sensible heat. With this option, the ACM must account for heat wheel motor energy and accounts for additional coil pressure drops.

DOE Keyword: RECOVERY-EFF
SUPPLY-1 thru SUPPLY-5
DEMAND-1 thru DEMAND-5

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model heat recovery options in the proposed design as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.6 Proposed System Types

Description: ACMs may model HVAC system types not included in the list of 5 minimum standard and proposed system types. Specifically, ACMs may model the following proposed system types:

- **System 6:** *Hydronic Heat Pump.* Zone cooling/heating capability may be provided by a zonal hydronic heat pump connected to a central water heat source/heat rejection loop, shared by other zonal hydronic heat pumps.

- **System 7:** *Single Fan/Dual Duct.* A single fan blows supply air through the heating and cooling coils and into the hot and cold supply ducts, with either a constant or variable volume fan. Zone terminal units mix hot and cold supply air streams to meet zone loads.

- **System 8:** *Dual Fan/Dual Duct.* Two separate central fan systems, one for heating and one for cooling, using either constant or variable fans, distribute air to the building. Zone terminal units mix hot and cold supply air streams to meet zone loads. **If this system is included, the ACM must also simulate heating supply air reset, described below.**

- **System 9:** *Direct and Indirect Evaporative Cooling*. Evaporative cooling may be modeled as the only cooling system or as a precooler for another cooling system. The systems may utilize direct evaporative cooling only; indirect evaporative cooling only; indirect/direct evaporative cooling; or

evaporatively precooled condensers. Direct or indirect evaporative precooling of supply air may also be modeled but no tests or specifications are defined for these options. Users must be able to specify evaporative cooler fan capacity and brake horsepower (bhp), water pump capacity and brake horsepower (bhp), and whether or not the evaporative cooler can operates in conjunction with another cooling system. When evaporative cooling systems are modeled, default measures of direct and indirect (where applicable) cooling efficiencies must be supplied. Subject to Commission approval, the user may be allowed to override these defaults.

Perimeter Systems. Independent HVAC systems (typically heating only) which serve perimeter zones in addition to a primary system (typically cooling only). Perimeter systems differ from zone terminal systems in that they are independent: They do not connect to the primary system but supply heating/cooling through separate air outlets or heat transfer surfaces. There are two common types of perimeter systems.

- **System 10:** *Convective/radiant*. Zone perimeter system may be a convective or radiant system, such as baseboard or radiant ceiling panels.

- **System 11:** *Constant volume system.* Zone perimeter system provides heating/cooling by constant air volume supply to each zone served. System may or may not have outside air supply capability.

Perimeter systems may incorporate the following features **(NOTE that perimeter systems may be specified as serving the same zone(s) as any of Systems 1 through 9)**:

- *Master zone.* Used when the perimeter system heating/cooling supply is controlled to satisfy the thermostat of a given zone.

- *Multiple zones.* Used when the perimeter system serves more than one zone of the primary system. (This allows modeling of "fighting" between the primary and perimeter system.)

- *Electric.* Used when the perimeter system heating is electric resistance.

- *Hydronic.* Used when the perimeter system cooling/heating coil is served by a central hydronic system.

- *DX.* Used when the perimeter system cooling is provided by direct expansion refrigerant coils served by a heat pump or other compression system (see PLANT equipment.)

DOE Keyword: SYSTEM-TYPE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Optional proposed systems shall be modeled as input by the user, according to the plans and specifications for the building, subject to all of the restrictions specified in the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (New): Standard system types and applicable system parameters are chosen according to Figure 2-1. The air flow and supply air temperature for the standard design will be optimally controlled in the reference method. All efficiency descriptors shall be determined according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using DOE-2 default performance curves. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.7 Combined Hydronic Systems for Nonresidential Buildings

Description: Combined hydronic water heating systems for nonresidential buildings may be modeled as an optional capability. Vendor-proposed prescribed assumptions for this method are crucial. All user-defined inputs must be enforceable. Variables which are difficult to plan and field verify should be incorporated as prescribed inputs. The residential water heating calculation methodology is a useful example for compliance-based combined hydronic heating system modeling.

3.5.2.8 Combined Hydronic Systems for High-Rise Residential Buildings

Description: Combined hydronic water heating systems evaluation for high-rise residential buildings should be evaluated in a manner consistent with the low-rise residential combined hydronic system methodology. A vendor-proposed optional capability should incorporate the majority of efficiency measures evaluated by the low-rise residential method and should be reasonably consistent with those procedures, especially near the transition between low-rise and high-rise buildings. Inputs and analysis of wood stoves and wood-fired boiler are not required (in fact discouraged) to be included as part of the optional capability.

3.5.2.9 Equipment Efficiency

Description: ACMs may model equipment according to factory supplied performance data. The following performance relationships may be modeled:

- *All Packaged Cooling Equipment*
  - Capacity as a function of entering wet-bulb and outside dry-bulb temperatures
  - Cooling electrical efficiency as a function of entering wet-bulb and outside dry-bulb temperatures
  - Cooling electrical efficiency as a function of part-load ratio
  - Sensible cooling capacity as a function of entering wet-bulb and outside dry-bulb temperatures

- *Packaged VAV Cooling Equipment Only*

- Capacity as a function of supply air quantity
- Cooling electrical efficiency as a function of supply air quantity
- Sensible cooling capacity as a function of supply air quantity

- *Water Chillers*
  - Capacity as a function of exiting chilled water and entering condenser water temperatures
  - Cooling electrical efficiency as a function of exiting chilled water and entering condenser temperatures

- *Furnaces*
  - Fossil fuel furnace efficiency

- *Heat Pumps*
  - Heating electrical efficiency as a function of outdoor dry-bulb and entering dry-bulb temperature

- *Boilers*
  - Fossil fuel boiler efficiency

DOE Keyword: COOLING-EIR
HEATING-HIR
FURNACE-HIR
HW-BOILER-HIR
BOILER-EIR
BOILER-HIR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model performance of proposed systems and plant equipment, except for fans, using DOE-2 default performance curves for the equipment specified in the construction documents for the building.

Low Value: Minimum efficiency requirement

Modeling Rules for Reference Design (New): ACMs shall model performance of all systems and plant equipment, except for fans, according to requirements of the Required Systems and Plant Capabilities, and the default performance curves listed in the DOE 2.1E supplement.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using the system's actual efficiencies according to requirements of the Required Systems and Plant Capabilities and DOE-2 default performance curves. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.10 Cooling Towers

Description: ACMs may model several options for cooling tower operation which may be specified at the user's option. These options are described below:

- *Closed circuit.* Condenser water is cooled indirectly by a heat exchanger which is evaporatively cooled (fluid cooler). With this option, the ACM must account for spray pump energy. If the ACM has this capability, it must require the user to specify if the cooling tower uses an open or closed circuit.

- *Axial fan.* An axial fan provides ambient air flow across tower fill or closed tower heat exchanger.

- *Natural draft.* Ambient air flow across tower fill is natural draft (not mechanically driven) as defined by user input tower dimensional data and draft factor.

- *Discharge dampers.* Tower (condenser) capacity is controlled by modulating fan discharge dampers.

- *Bypass.* Tower leaving water temperature is controlled by bypassing tower return water around tower to the supply line, thereby cooling only a portion of the water flow.

- *Variable speed drive:* Tower (condenser) capacity is controlled by varying fan motor speed.

DOE Keyword: TWR-CAP-CTRL
TWR-MIN-FAN-SPEED
FLUID-BYPASS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model all optional cooling tower features as input by the user according to the construction documents for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using the system's actual efficiencies. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.11 Pump Controls

Description: ACMs may model several optional pump design, operation and control strategies which may be specified at the user's option. These options are described below:

- *Variable flow.* Used when the variable flow, constant temperature system flow rate varies as a function of load.

- *Riding curve.* Pump(s) ride characteristic performance curve as a function of head pressure. Head pressure will vary depending on the water demands of cooling and heating coils and the amount of water bypassing different zones.

- *Two speed/stages.* Used when the pumps are staged, or pump has two speed motor, to maintain pressure requirements. Pump(s) ride characteristic curve between stages.

DOE Keyword: TWR-PUMP-HEAD
TWR-IMPELLER-EFF
TWR-MOTOR-EFF
CIRC-IMPELLER-EFF
CIRC-MOTOR-EFF
CIRC-HEAD
CIRC-PUMP-TYPE
DHW-PUMP-ELE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model optional features of proposed design pumping systems as input by the user according to plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.12 Fan Volume Control

Description: The ACM may model the following optional types of fan volume control, as input by the user. Default fan curves are given in terms of DOE-2 curve-fit instructions.

- *Air foil centrifugal fan with discharge dampers (ride fan curve).* Fan volume is controlled by a controllable damper mounted at the fan discharge, or the fan "rides" its characteristic fan curve against varying system pressure.

```
AF-FAN-W/DAMPERS = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.68
DATA =      (1.0,1.0)
            (0.9,0.95)
            (0.8,0.90)
            (0.7,0.86)
```

(0.6,0.79)
(0.5,0.71) ..

- *Vane-axial fan with variable pitched blades.* Fan volume is controlled by varying blade pitch.

VANE-AXIAL-FAN = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.15
DATA = (1.0,1.0)
(0.9,0.78)
(0.8,0.60)
(0.7,0.48)
(0.6,0.36)
(0.5,0.27)
(0.4,0.20)
(0.3,0.23)
(0.2,0.22) ..

DOE Keyword: FAN-CONTROL

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall model supply and return fans chosen by the user and as documented on the plans and specifications for the building for the proposed design fan system. The ACM shall use the performance data given in this manual.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.13 Multiple Fan Volume Controls

Description: ACMs may model different fan volume control strategies for supply, return and relief fans. If the ACM has this capability the user may specify a different strategy for each fan in the fan system.

DOE Keyword: FAN-CONTROL

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model fan volume controls for each proposed design fan as input by the user. If different fan volume controls are not input for supply, return and/or relief fans, the ACM shall assume all fan volume controls for the entire fan system to be the same as that specified for the supply fan.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.14 Air Economizers

Description: The ACM may model the following optional economizer control strategies when specified by the user:

- *Outside air enthalpy.* Economizer cooling is enabled as long as the outside air enthalpy is less than 29 Btu/lb.
- *Variable enthalpy*. Equivalent to the Honeywell W7400 or H205 humidity biased enthalpy control using set-curve A.
- *Differential dry-bulb.* Economizer cooling is enabled as long as the return air temperature is greater than the outside air temperature.
- *Differential enthalpy.* Economizer cooling is enabled as long as the return air enthalpy is greater than the outside air enthalpy.
- *Economizer High Limit.* When a differential controller is used, a high limit, above which the economizer cannot operate, may also be added. The high limit controller can either be a dry-bulb (set at 75 degrees), an enthalpy (set at 29 Btu/lb) or a variable enthalpy controller.
- *Non-integrated, two stage operation*. The economizer operates as the first stage of cooling until the cooling load cannot be met by the economizer. At this point, the economizer closes to the minimum position and mechanical cooling is used to meet the cooling load. If this strategy is selected, an outdoor high limit of 70 ODB or 28.5 Btu/lb shall be used.

DOE Keyword: OA-CONTROL
ECONO-LIMIT-T
ECONO-LOCKOUT
ENTHALPY-LIMIT
DRYBULB-LIMIT

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall limit proposed design optional economizer control strategies to those listed in this section, including set points.

Default: No economizer

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.15 Water Side Economizers

Description: ACMs may model the following water side economizers when specified by the user:

- *Strainer cycle*. Used when cooling tower water is diverted to the main cooling coil for "free cooling" when the cooling tower leaving water temperature is low enough to meet the total building load. This type of water side economizer can only be used in place of, and cannot be used to supplement, mechanical cooling.

- *Series coil*. A cooling coil, connected to the condenser water loop ahead of the condenser, is placed in the air handler upstream of the main cooling coil. This coil is used to supplement mechanical cooling, when the cooling benefit is greater than the added pumping energy needed to circulate cooling tower water through the cooling coil.

- *Evaporator precooling (heat exchanger)*. A heat exchanger is used to transfer heat from condenser water, prior to entering the condenser, and chilled water, prior to entering the evaporator, in order to precool the chilled water. If the difference between the return chilled water temperature and cooling tower leaving water temperature is large enough to provide a cooling benefit, the heat exchanger is used to supplement mechanical cooling.

- *Evaporator precooling (cooling tower)*. Chilled water is circulated through a closed loop in the cooling tower before entering the evaporator. If the difference between the chilled water return temperature and outside wet-bulb temperature is large enough to provide a cooling benefit, chilled water is circulated to the cooling tower to supplement mechanical cooling.

DOE Keyword: WS-ECONO
WS-ECONO-MIN-DT
WS-ECONO-XEFF
CONDENSER-TYPE
FLUID-VOLUME

COND-FLOW-TYPE
COND-WTR-FLOW

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model the proposed system water side economizer as input by the user, according to the plans and specifications for the building. If a strainer cycle is specified, change-over temperature from economizer to mechanical cooling must be set at 50 ^{o}F.

Default: No economizer

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.16 Zone Terminal Controls

Description: ACMs may model the following optional features for zone terminal controls, as input by the user:

- *Constant volume.* Zone receives a constant volume of air regardless of thermostat signal.
- *Mixing hot deck/cold deck.* Zone temperature is controlled by mixing hot and cold air.
- *Induction.* Supply air induces room or return plenum air into the supply air stream.
- *Fan powered induction.* Zonal fan supplies return or room air optionally mixed with system supply air (if any).
- *Series.* Fan powered induction system where zonal fan is in series with primary system supply air. Fan runs continuously when central system is on providing constant volume to space.
- *Parallel.* Fan powered induction system where zonal fan is in parallel with primary system supply air. Primary supply is usually VAV. Fan cycles on only when heating is required.
- *Series/Parallel.* Fan powered induction system where zonal fan is in parallel with primary system supply air. Primary supply is usually VAV. Fan cycles

on to maintain a minimum supply volume and when heating is required.

DOE Keyword: TERMINAL-TYPE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model optional zone terminal control features as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.17 Renewables

Description: The depletable energy savings associated with solar collector systems must be analyzed according to certified methods such as f-Chart which have been approved by the Commission for use with the low-rise residential standards (see *Alternative Calculation Method (ACM) Approval Manual for the ~~1998~~2001 Energy Efficiency Standards for Residential Buildings*). A nonresidential ACM may be approved with the optional capabilities of built-in f-Chart and/or passive solar collector performance calculations.

Vendors who wish to have their nonresidential ACMs approved with either of these capabilities must meet the requirements described in the residential ACM manual.

DOE Keyword: N/A

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs may model solar water heating as an energy source for service hot water heating only.

Default: No renewable energy is used.

Modeling Rules for Reference Design (New): ACMs shall not model renewable energy sources for any of the standard design energy use.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.6 Vendor Defined Optional Capabilities

Vendors may propose other optional capabilities not specifically described in this manual. In the proposal for vendor specified optional capabilities, the vendor shall include:

- Theoretical background and simulation algorithms
- Testing data and validation analysis for all specified capabilities
- Standard and proposed design assumptions
- Specific documentation requirements, addressing enforceability by building department personnel

The Commission, during the certification process, may require changes to the vendors' proposed methods in order to gain consistency with other vendors' proposing similar capabilities.